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Military Organizations and Systems: Human Factors Research Projects

by

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This report summarizes five research efforts conducted between May 1976 and May 1977 at Fort Hood, Texas and dealing with aspects of the field assessment of human performance factors in developmental military systems. Separate reports provide more detail for each effort:

(1) Study of target Handoff Techniques, ARI TR-78-A34, investigated the verbal interchange in simulated ground-to-air and air-to-ground target handoffs.

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(2) A Study of Selected Problems in Armor Operations, ARI TR-78-A35, investigated target acquisition performance and internal temperatures in buttoned-up tanks; escape modes; and crew effectiveness measures.

(3) Problems in Helicopter Gunnery, ARI TR-78-A36, investigated distance recognition of target vehicles.

(4) Statistical Analysis of the Fort Hood Quality-of-Life Questionnaire, ARI Research Memorandum 78-25, tabulated variables, analyses, and computer correlations (available directly from the Army Research Institute).

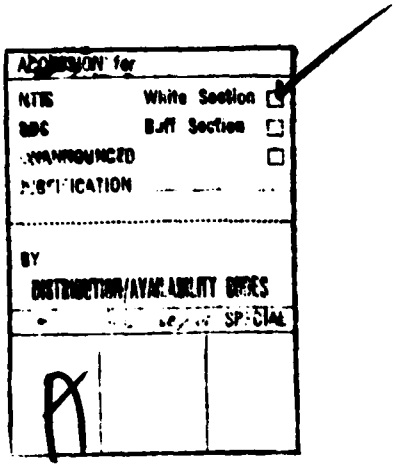
(5) The Detection Ranges of Features of Armored Vehicles, ARI TR-78-A37, investigated the actual ranges at which specific identification of target vehicles can be made.

FOREWORD

This report summarizes the results of five research efforts conducted in support of the US Army Research Institute for the Behavioral and Social Sciences (US/ARI) Field Unit at Fort Hood, Texas. Separate, more detailed reports describing the work in each of the five areas are also being published concurrently.

This research was conducted as the second year's effort under Contract DAHC19-75-C-0025 under the sponsorship of US/ARI. Administrative and logistical support was provided by the US/ARI Field Unit, Fort Hood, Texas, under the direction of Mr. George Gividen. Dr. Charles Nystrom served as the Contracting Officer's Technical Representative (COTR). The purpose of the overall effort was to provide human factors support to the US/ARI Field Unit, Fort Hood, in five specific areas: target handoff techniques, effects of special hatches and other factors on tank crew performance, helicopter aircrew workload, analysis of data related to improving unit operational and training effectiveness, and long range target acquisition.

The overall research effort was under the direction of Dr. Albert L. Kubala, Team Chief, HumRRO Team-Fort Hood. The HumRRO Team is a unit of the Western Division of HumRRO. Dr. Howard H. McFann, Vice President, HumRRO, is Director of the Western Division and provides general supervision for all Division personnel. Ms. Nancy Lawson assisted in the acquisition of bibliographic materials and the production of typed manuscripts.



MILITARY ORGANIZATIONS AND SYSTEMS: HUMAN FACTORS RESEARCH PROJECTS

BRIEF

Requirement:

Both the accuracy and lethality as well as the variety of weapons in the arsenals of today's major powers has greatly increased during the period since the Korean conflict. As a result, new tactics have been developed, and the wars of the future are not expected to be like those of the past. The US Army must be prepared to fight in conflicts where friendly forces are outnumbered, have doubtful air superiority, and are faced with the potential use of unconventional weapons. Human factors considerations in the conduct of this type of conflict are quite different than in the past. A requirement exists to determine just what these considerations are. This effort examined five specific areas.

The objectives were:

- To determine how air-to-ground and ground-to-air target handoff has been accomplished in the past, and to develop techniques for low-cost experimental studies of target handoff in order to develop new procedures and specify requirements for new equipment.
- To determine the effects on tank crew performance of special hatches and other factors, and to plan experimental studies aimed at solving selected major problems. Tank crew Measures of Effectiveness (MOE) must also be delineated as part of this research.
- To determine the effectiveness of current training in target identification.
- To determine the ranges at which various target features can be recognized.
- To analyze selected data from the ARI Quality-of-Life questionnaire.

Procedure:

A staff member was assigned primary responsibility for each of the research areas. A significant portion of the time on each of the efforts was expended in the search for and accumulation of relevant information. Information was sought through the Defense Documentation Center (DDC), University of Texas libraries, HumRRO libraries in other locations, and through personal contacts. Reviews of the documentation are included as appropriate in each report.

Principal Findings:

Target Handoff. An attempt was made to develop a battery of paper-and-pencil tests for selection or classification of individuals who must

perform target handoff as part of their job. This effort did not produce a practically useful result. Recordings were obtained of the verbal interchange between individuals performing simulated handoffs. These handoffs were submitted to the initial stages of a content analysis. This analysis may provide useful cues as to the characteristics of effective verbal behavior during handoff.

Special Hatches. Two experimental studies concerned with target acquisition were accomplished as part of this effort. A study of the effects of external environmental factors on the habitability of armored vehicles was also done. In addition, a literature survey on crew Measures of Effectivness (MOE) was carried out. The first two studies showed no evidence of degradation of target acquisition performance under any of the experimental conditions. The environmental effects study showed that in an unoccupied, stationary tank, the effective temperature exceeded levels necessary for the comfort and effectiveness of personnel. The MOE literature survey revealed that there is a great need for validated crew MOE. A program of research aimed at developing the needed MOE is proposed.

As a final effort, information on the kind and extent of training in escape and/or evacuation of tank crewmen was obtained by a questionnaire. This effort revealed that current training is nonexistent, and that the gunner is the most vulnerable crew member.

Problems in Helicopter Gunnery. The effort consisted of two studies designed to determine (a) whether targets can be identified by air crewmen at ranges in excess of 3000 meters, and (b) whether current training meets the needs for long range target identification. Reduced-scale techniques were employed. The principal findings were:

- Helicopter crewmen could recognize and identify the armored vehicles at scaled ranges of 3000 and 4000 meters.
- All of the helicopter crewmen who served as observers in these experiments were able to learn to recognize and identify the armored vehicles to a level of almost 100 percent correct.
- Target view was found to be the only factor significantly related to recognition and identification performance. Differences in recognition and identification performance at the two different ranges (3000 and 4000 meters) were not statistically significant. Likewise, differences in recognition and identification performance for the five target vehicles were not statistically significant.

Detection Ranges of Features of Armored Vehicles. This small-scale effort was undertaken to determine the actual ranges at which various features of vehicles can be recognized. Reduced-scale techniques were employed. The principal findings were:

- A number of the recognition features stressed in current training programs were not seen until the observer was very close to the target (number of road wheels and gun tubes, sprocket location, and number of rollers, for example).

- The determination of turret shape, a major recognition feature, occurred earlier for the bowl shaped turrets than for other shapes. This type of turret is used more often on Soviet type vehicles than on NATO vehicles.
- The only features seen at scaled distances greater than 1200 meters were (a) tracked vs. wheeled, (b) presence of a turret, and (c) turret location. All other features were seen at closer distances.
- The detection ranges for features did not appear to be related to amount of prior experience, but seemed to depend on the observer's risk-taking propensity.

Analysis of the Quality-of-Life Questionnaire. The intent of this effort was to provide ARI with support in the area of data analysis. The required analyses were accomplished and are being transmitted to ARI. No conclusions or interpretation were required.

CONTENTS

MILITARY ORGANIZATIONS AND SYSTEMS: HUMAN FACTORS RESEARCH PROJECTS

The research described in this report was conducted by the Human Resources Research Organization (HumRRO) under contract to the US Army Research Institute for the Behavioral and Social Sciences (US/ARI). The contract number was DAHC19-75-C-0025. The work described herein was conducted during the second year of the contract, from 12 May 1976, to 11 May 1977.

Five research problems were specified in the Scope of Work for the second year. These were titled: (a) *Study of Target Handoff Techniques*, (b) *Effects of Tank Crew Performance of Special Hatches and Other Factors*, (c) *Pilot and Aircrew Workload Assessment*, (d) *Improved Unit Operational and Training Effectiveness*, and (e) *Target Identification at Long Ranges*. Interim reports describing the work in each of these five areas are being published separately. However, the titles of some reports have been changed somewhat from those shown in the contract. This was done primarily to make the titles more specific, and does not reflect a deviation from the objectives outlined in the Scope of Work.

Most of the work was performed at Fort Hood, Texas. Logistical support was provided by the ARI Field Unit, Fort Hood, and Headquarters, TRADOC Combined Arms Test Activity (TCATA). Personnel and equipment for field tests were provided by the 1st Cavalry Division, the 2nd Armored Division, and the 6th Cavalry Brigade (Air Combat).

The work on long range target identification was performed at Fort Bliss, Texas. The analysis of the data on unit operational and training effectiveness was accomplished at Carmel, California.

The major problem encountered was the inability of the TOE Units at Fort Hood to supply the desired levels of support for planned field research. The Army's austerity program, which has seriously curtailed fuel supplies, made it possible for units to support only the highest priority research and maintain a minimal training program to ensure combat readiness. Also, other equipment such as voice recorders, 35mm slide projectors, and electronic stopclocks were not always available, and had to be obtained from other HumRRO units. However, all of the scheduled research was completed, generally with fewer subjects than would have been desirable.

Bibliographic information on the other reports submitted are presented at the end of this summary report. Brief summaries of the work accomplished in each of the areas are presented below.

STUDY OF TARGET HANDOFF TECHNIQUES

Background and Problem

It has been noted that it is relatively easy for ground observers to handoff (designate) ground targets to other ground elements. In this instance, both are viewing the target and surrounding terrain from a similar aerial perspective. The task becomes more difficult when a scout helicopter designates targets for Attack Helicopters (AHs) as the aerial perspective from which both are viewing the target differ, to an unknown extent. However, air-to-ground and ground-to-air handoffs are the most difficult. The common denominator in all of these situations is the difference in viewing perspective between the two individuals attempting a handoff. Because of this fundamental similarity, an improvement in handoff techniques for one situation should apply to all.

The overall research program was undertaken in an attempt to derive more efficient techniques and procedures for handing off of targets. More specifically, this present research was designed to investigate the role of verbal and perceptual abilities in target handoff.

Procedures

During the previous year, the feasibility of employing a low-cost simulator in studying target handoff was investigated. The simulation employed static imagery. A "sender" and a "receiver" each viewed a scene which contained some target object. However, the perspective to and the range from the target differed in the two images. The sender's job was to help the receiver locate the target in the receiver's image by verbally describing the target and its location. The concept proved to be feasible, and participants generally agreed that the simulation contained the essential characteristics of handoffs in an operational setting. Therefore, a more sophisticated simulator was designed, and a full-scale study was planned for the second year.

The study utilized 58 pairs of individuals, the majority of whom were air crewmen. All individuals first received a battery of perceptual and verbal tests, and completed a short personal data form. After completing the tests, individuals were paired and proceeded to attempt handoffs in six simulated situations. Time to successfully achieve a handoff was recorded in each instance, and the verbal interchange between the pairs was recorded.

Two types of data analyses were conducted. The first analysis was designed to determine whether perceptual and/or verbal abilities played a significant role in success/non-success handoff performance. Success-

ful handoffs were defined as those which required less than the median time to achieve.

The second analysis was concerned with the content of the handoff messages. An attempt was made to determine whether successful handoff measures consistently contained any particular set of characteristics.

Results

The principal findings of this research were:

a. The battery of spatial and verbal tests was relatively ineffective in identifying successful handoff performance.

b. Successful utilization of the test battery would require selecting only the top scorers on the tests used.

c. Faster handoffs use fewer words.

d. Faster handoffs occur when the observer does most of the talking.

e. A high ratio of adjectives relative to nouns is associated with rapid handoff.

f. It is probably not possible to attempt to devise a specific set of rules which will apply to all possible handoffs. A more general set of rules is indicated.

g. The ideas embodied in handoff simulation seem to form the basis for an effective program of the study of target handoff.

A STUDY OF SELECTED PROBLEMS IN ARMOR OPERATIONS

Background and Problem

US tank crews in any future conflict are likely to face a number of circumstances never before faced by US forces. They are expected to be

outnumbered, and to face an enemy whose weapons are as good as, or almost as good as, ours. In order to win against these odds, they must be the best trained and most effective fighting force in the world.

A number of problems in armor operations were unearthed in previous research by ARI and TCATA. Others were found in concerns expressed by operational armor units at Fort Hood. Four of these problems were addressed during the past year in separate efforts. These four efforts were designed to meet the problems implied in the following objectives:

- To determine the effects of external environmental conditions on the internal environment of a buttoned-up tank.
- To determine the kind and extent of training currently provided in escape and/or evacuation of wounded or injured personnel from armored vehicles; to obtain crewmen opinions concerning the adequacy of current escape and evacuation systems; and to determine what design changes crewmen feel should be made in escape and evacuation systems.
- To determine what factors influence target acquisition performance of tank commanders in the closed-hatch mode.
- To determine the problems involved in the development of Measures of Effectiveness (MOE) for tank crews, and to determine the research needed to develop a reliable, valid, and comprehensive set of MOE.

Procedures

Work towards meeting each of the objectives was conducted independently. The procedures followed in each case are outlined below.

In order to determine how external conditions affect the internal environment of a tank, a recording hygro-thermograph was placed in an M48 tank. The tank was sealed, and data on internal temperature and relative humidity were obtained over a several day period in late summer. These data were then compared with comparable data obtained outside the tank. There were no personnel in the tank, and the engine was not running. Therefore, it was realized that the temperature and humidity inside the tank would both have been greater under operational conditions.

Information on the kind and extent of training in escape and/or evacuation of wounded or injured personnel were obtained by a questionnaire. Thirty-three crewmen with some actual experience in escape and/or evacuation served as subjects. Opinion data were also obtained concerning needed design changes and the adequacy of current escape and evacuation systems.

Target acquisition performance of tank commanders operating in the closed-hatch mode was investigated in two experimental studies. Factors examined included slew rates, cupola position, and the use of an aiming reference. Performance data under different conditions were obtained for each tank commander involved, and these data were compared to performance in the normal open-hatch mode.

A review of the relevant literature was conducted in an effort to determine the problems involved and the methods typically employed in the development of MOE for crews or larger personnel units. Extensive contacts were also made with other research personnel working in related areas. Based on the information obtained, a program of research was outlined aimed at the development of MOE for tank crews.

Results

The principal findings of this research effort were:

a. Temperature and relative humidity inside a buttoned-up tank lag temperature and relative humidity outside the tank by approximately three hours.

b. Effective temperatures inside a buttoned-up tank in warm weather reach levels that can be expected to degrade performance.

c. Current training in escape and/or evacuation of injured or wounded personnel is extremely limited, and highly variable.

d. If a tank is hit, the gunner is the most vulnerable crew member, and will have the greatest difficulty in escaping.

e. Lifting straps built into a tanker's uniform would aid considerably in the evacuation of wounded or injured personnel.

f. Target acquisition performance is not affected significantly by either slew rate, cupola position, or the use of an aiming reference.

g. Target acquisition performance is not degraded in the closed-hatch mode.

h. Techniques for derivation of MOE for crews or larger personnel units are not well developed.

i. The only current work of any magnitude being conducted in the area of MOE for tank crews is concerned with gunnery.

PROBLEMS IN HELICOPTER GUNNERY

Background and Problem

The threat forces likely to be engaged by US and other NATO units in a mid- to high-intensity conflict in Europe are equipped with sophis-

ticated air defense systems in the forward areas. They are also quite sophisticated in electronic warfare, and have the capability to fight effectively at night as well as day.

These capabilities create a number of problems for helicopter crewmen. They may be called upon at virtually any time, and must be prepared to fight at night after having flown daytime missions. They must also be able to fight at standoff ranges (i.e., in excess of 3000 meters), or become extremely vulnerable to air defense weapons. The COBRA-TOW system was developed in order to permit the Attack Helicopter (AH) to engage at standoff ranges. However, effective use of this weapon places an additional burden on the crewmen, as they must be able to positively identify a target as a threat before engaging. Authorities at the 6th Cavalry Brigade (Air Combat) were concerned about the ability of crewmen to identify targets at standoff ranges, and about the adequacy of current training in target recognition. They were also concerned over reported fatigue resulting from the use of the CAV/NAV night vision goggles.

This research project primarily addressed the target identification problems. However, because of the concern expressed over night missions, a brief literature review in this area was also accomplished. The experimental portion of the effort was directed toward the identification and training problems, and had the following objectives.

- To determine whether helicopter crewmen, who had received previous training in armored vehicle identification, could recognize and identify armored vehicles at the standoff ranges (3000 to 4000 meters) made necessary by modern battlefield conditions (Recognition was defined as labeling a vehicle as

friendly or threat. Identification meant specifically labeling a vehicle as an M60, T54, Chieftain, etc.)

- To determine whether helicopter crewmen could be trained to identify armored vehicles at standoff ranges with near-perfect accuracy.

Procedures

Scale model armored vehicles were presented to observers at scaled ranges calculated to simulate full-scale ranges of 3000 and 4000 meters. Two experiments were designed and carried out, the first one being a preliminary, exploratory experiment, and the second one a larger experiment designed on the basis of lessons learned from the preliminary experiment. The observers used optical aids to view the scale model armored vehicles; 7x50 binoculars were used in the preliminary experiment, and the XM65 gunsight in an AH in the main experiment.

The experiments were designed to provide information on the pretraining recognition and identification capabilities of the observers, their performance during training, and their posttraining recognition and identification capabilities. Scale models of five different armored vehicles (M60 tank, M113 Armored Personnel Carrier, Chieftain tank, T54 tank, and ZSU 57/2 Air Defense System) were used throughout the experiments. Two additional vehicles (AMX 30 tank and PT 76 Armored Reconnaissance Vehicle) were introduced during the posttraining phase of the experiments to test the reactions of the observers to unfamiliar vehicles. The scale model armored vehicles were presented in five different views: side left, oblique left, front, oblique right, and side right.

Results

The literature survey on the use of the CAV/NAV night vision goggles revealed no previous research on fatigue effects. However, in conversations with both aviators and other research personnel, anecdotal evidence of fatigue was abundant.

The two experiments conducted in the area of target identification and recognition produced useful results. In essence, these were:

a. Helicopter crewmen could recognize and identify the armored vehicles at scaled ranges of 3000 and 4000 meters. Pretraining recognition performance averaged from 76 percent to 96 percent correct for the five armored vehicles. Pretraining identification performance averaged from 48 percent to 77 percent correct for the five vehicles. During this experiments viewing was carried out under relatively ideal conditions.

b. All observers in these experiments were able to learn to recognize and identify the sample of armored vehicles with nearly 100 percent accuracy.

c. Target view was found to be significantly related to recognition and identification performance. Differences in recognition and identification performance at the two different ranges (3000 and 4000 meters) were not statistically significant. Likewise, differences in recognition and identification performance for the five target vehicles were not statistically significant.

STATISTICAL ANALYSIS OF THE FORT HOOD QUALITY-OF-LIFE QUESTIONNAIRE

Background and Problem

During the Fall of 1975, the SGS, III Corps requested that the Army Research Institute assist in the development of a questionnaire to be

used in determining the quality of life at Fort Hood. The questionnaire was to be administered to individuals of ranks E1 through E4. ARI was asked to assist in determining what soldiers thought of their training at Fort Hood, how satisfied they were with off-duty activities, their perception of their commanders' open door policies, and a variety of other areas relating to job satisfaction and quality of life at Fort Hood. A questionnaire was therefore developed which was designed to answer not only specific questions, but which would also measure, in a more general way, satisfaction with the various aspects of Army life on Fort Hood.

The questionnaire underwent two pilot tests and revisions prior to being administered at the end of 1975.

The sample of respondents was drawn from the 1st Cavalry, 2nd Armored Division, 57th Signal Battalion, 163rd Military Intelligence Battalion, 720th Military Battalion, and HHC III Corps. Within each of these units sampling procedures were used which would permit the sample to be representative of that unit. In order to justifiably generalize the questionnaire results to the population as a whole, the total sample represented proportionately each of the units tested.

Only 89 questionnaires from the 1st Cavalry were included in the primary sample. However, it was necessary to examine a considerably larger sample there, primarily because ARI was asked by the 1st Cavalry to give them a comparison between sex and racial groups. In order to have large enough samples to make comparisons between the various sex and racial groups, it was necessary to increase the number of female soldiers in the sample, both Afro-American and Caucasian. Thus, a total of 168 soldiers from the 1st Cavalry were sampled.

HumRRO was requested by ARI, as an expansion of the Fort Hood effort, to undertake supplementary analyses. The analyses were performed as directed by the responsible ARI staff member. This work was carried out at HumRRO's Carmel, California office.

Procedures

The Quality-of-Life questionnaire data were transmitted to HumRRO on magnetic tape. The tape was read and the required data reproduced on cards. The data consisted of the responses of 215 individuals to the Quality-of-Life questionnaire. These data were then intensively analyzed using analysis of variance and correlational techniques. The results of these analyses are presented in the body of the report. As the project involved only analyses, no conclusions were reached.

THE DETECTION RANGES OF FEATURES OF ARMORED VEHICLES

Background and Problem

This study was conducted in response to a Human Resources Need (HRN) statement prepared by the 6th US Cavalry Brigade (Air Combat), Fort Hood, Texas. The overall requirement concerned target identification by helicopter crewmen. More specifically, the Brigade was concerned about the adequacy of the current training methods used for training vehicle identification.

A review of existing training programs indicated that, generally, these programs concentrate on teaching the recognition of the features that can be used to distinguish among various armored vehicles, irrespective of the visibility of such features at different distances. In fact, the results of a pilot test conducted at Fort Hood indicated that

many targets are incorrectly named because the presence of a specific recognition feature could not be discerned. It was apparent that there is a need for valid information concerning the distances at which the recognition features of armored vehicles can be detected under a wide variety of viewing and environmental conditions. As an initial step a limited experiment was conducted to obtain measures of the detection ranges for vehicular features under optimum conditions.

Procedures

Models of 20 armored vehicles were presented to observers who moved toward the targets from a maximum scaled distances of 4000 meters to a minimum minimum scaled distance of 100 meters. As the observers approached the scale models, they reported when detection of the various recognition features occurred. The observers were not required to name the vehicle. The models were oriented at an angle of 45 degrees with respect to the observer and included two wheeled and 18 tracked vehicles. All observations were made with unaided vision (that is, without optical aids).

Results

The principal findings of this study were:

a. A number of the recognition features stressed in current training programs were not seen until the observer was very close to the target (number of road wheels and gun tubes, sprocket location, and number of rollers, for example).

b. The determination of turret shape, a major recognition feature, occurred earlier for the bowl shaped turrets than for other shapes. This type of turret is used more often on Soviet type vehicles than on NATO vehicles.

c. The only features seen at scaled distances greater than 1200 meters were (1) tracked vs. wheeled, (2) presence of a turret, and (3) turret location. All other features were seen at closer distances.

d. The detection ranges for features did not appear to be related to amount of prior experience, but seemed to depend on the observer's risk-taking propensity.

BIBLIOGRAPHIC INFORMATION

The reports summarized can be identified separately by the following information:

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